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Development of high(er) resolution MPI-ESM

We have been working on the latest version of the MPI-ESM (MPI-ESM-1.2). A control run in the resolution of T127 for ECHAM and TP04 for MPIOM has been run in total for 900 years. After finalizing the version, the last 300 years of the run is performed with fixed parameters. A major bug of the higher resolution version (T255 ECHAM coupled to TP04), characterized by strips of SST biases in the tropical oceans, has been itendified. The problem is directly caused by the too coarse coupling frequency of once per day, which is a standard for MPI-ESM simulations. When increasing atmospheric resolution from T127 to T255, the daily coupling frequency produces unrealistic features which are further emphasized by air-sea interactions. Even though increasing coupling frequency to once per hour removes the large SST biases in form of stripes in the tropical oceans, the new version of MPI-ESM at T255 version needs still be further tuned or run for longer time to spin up the ocean. Nevertheless, since the PRIMAVERA -simulations will directly start from 1950, a state derived either from observation or from a historical simulation using MPI-ESM at a lower resolution, the latest MPI-ESM with T255-ECHAM can, in principle, be used to run the PRIMAVERA flagship experiments.

Development of FESOM

We have been working on the development and testing of a high-resolution version of ECHAM6-FESOM. Atmospheric resolutions tested include T63, T127 and T255. For the ocean two meshes were employed: A low-resolution setup with spatial resolution ranging from 150—25 km (FESOM-LR) and a high-resolution setup where the resolution ranges from 100—7 km (FESOM-HR).

For the high-resolution version of FESOM the strength of grid refinement has been scaled by the observed variance of sea surface height (SSH). This argument for doing so is that the larger the SSH variance is, the more vigorous ocean eddy activity and hence the need for increased horizontal resolution is. Following this approach horizontal in regions such as the Gulf Stream, the Kuroshio and the Antarctic Circumpolar Current is increased down to 7 km. The horizontal resolution was also increased in some key straits and deep water production area. This configuration, which contains approximately 800000 horizontal nodes and 47 levels in the vertical, has high resolution in many of the dynamically “important” regions. For ocean-only configurations the performance is very promising, allowing a throughput of about 10 years per day in ocean-only configurations using about 2000 cores.

So far, multi-decadal simulations for the following setup have been produced:

- FESOM-LR/ECHAM-T63L47
- FESOM-HR/ECHAM-T63L47
- FESOM-LR/ECHAM-T127L95
- FESOM-HR/ECHAM-T127L95

Preliminary results with the high-resolution version of ECHAM6-FESOM are very promising, suggesting that deep biases in North Atlantic temperature are significantly reduced after 100 years of integration compared to the low-resolution version used in previous studies (Figure 1). Additional experimentation suggests that it is increased resolution in the ocean rather than the atmosphere, which explain these findings. Whether this improvement of the high-resolution version will also show for longer simulations remains to be shown. However, from these results it may be argued already that enhanced oceanic resolution may be beneficial for short-term climate predictions.

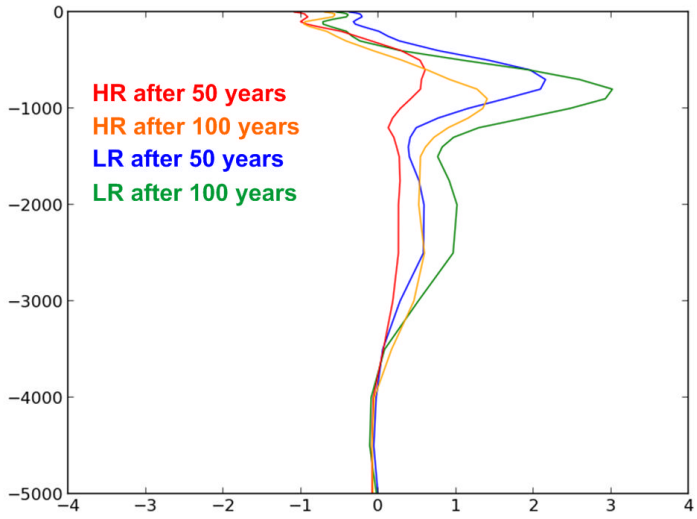

Figure 1: Temperature biases (^{o}C) averaged over the North Atlantic region as a function of depth (m) for FESOM-LR/ECHAM-T63L47 (LR) and FESOM-HR/ECHAM-T127/L95 (HR) for 50 and 100 years lead time after initialization.

Another interesting result is that episodic freezing of the Labrador Sea, which used to be a problem in earlier versions of ECHAM6-FESOM, has disappeared with the introduction of the latest version of ECHAM (version 6.3) as an atmospheric component.